SOIL CONSERVATION

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The native grasses, especially the big and little bluestems, return to a pasture given protection from fire and overgrazing. In the past this pasture was burned every year and was so badly overgrazed as to be almost entirely unfit for grazing.

Grass In Action

By Ivy M. Howard[1]

SOD-RIPPING plows that turned thousands of acres of Central Great Plains grass land "wrong-side-up" so that wheat could be grown for sale at sky-high World War prices are now growing rusty. The "marginal" lands, no longer profitable in wheat, are being once more planted to soil-saving and moisture-conserving grass.

Throughout Region 7 grass is being used as the Big Bertha in erosion control. Concrete and masonry structures—large, awe-inspiring, expensive masterpieces of engineering skill—have made their bow to the lowly bunches of fibrous-rooted grass. Take Oklahoma for example. In 38 counties where the Soil Conservation Service is cooperating with farmers in

Terrace outlet channel emptying into a good pasture sod, immediately after rainfall of 1 inch in half an hour. The water is spread out and allowed to filter away without erosion or cutting effects.

(Continued on next page)

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A stand of little bluestem acting as a retainer and collector of soil in the windy seasons of blow sand.

demonstrating best methods of soil conservation, 64,000 acres of land once in cultivation has been planted to grass and 5-year cooperative agreements call for the establishment of grass on 43,000 additional acres that are so scarred by serpent-like gullies that they are no longer profitable in clean-tilled crops.

GRASS as a weapon in erosion control has many uses other than that of revegetating fields taken out of cultivation. It is used to sod terrace outlets and outlet channels; it is used for gully control; it is used in buffer strips alternated with strips of clean-tilled crops to check soil losses on sloping fields that still possess much fertility; and it is used on contour pasture ridges and furrows.

In talking of the value of grass-covered furrows on an 80-acre pasture on his 160-acre Jewel County, Kans., farm, Ira L. White says, "Hardly a teacupful of water ran off the pasture when a 2-inch rain fell in June, as a result of the water held on the pasture. I believe its carrying capacity will be at least 30 percent greater than it was last year."

FARMERS throughout the Midwest are in harmony with White in voicing their praise for contour pasture furrows and ridges, which, 3 years ago, were little known and seldom, if every, used.

For sodding contour pasture ridges, controlling gullies, and protecting terrace outlets and outlet channels in the southern part of the region, Bermuda is recognized as a most valuable grass. Bromegrass is widely used in the northern part of the region. But it is in the native grasses that lie the fondest hopes of soil conservationists. The chief reliance is upon bluestems, buffalo, switch, blue grama, Indian, slough—these and a few other grasses that made the old Chisholm Trail practicable for cattlemen.

NATIVE grasses are being encouraged to return to eroding acres by fencing and artificial seeding. Thousands of acres of gullied land and land which has suffered severe sheet erosion in the Central Great Plains region have been fenced to encourage the return of natural vegetation. Observation shows that wherever plant cover is destroyed or the climax type of vegetation thinned a natural process of restoration sets to work as soon as the cause of disturbance is removed.

It has been demonstrated time and again that if land is protected from grazing, fire, and concentration of run-off water, it will soon be covered with soil-holding natural vegetation.

In encouraging the growth of native grasses by protecting them from the forces that have crowded them off the plains, land is not being retired. It is merely being rededicated to the production of crops for which it is well adapted. A gully controlled by natural vegetation may produce profitable timber and wildlife; a steep slope, naturally vegetated, may with exercise of a little caution against overgrazing be made to furnish economic crops of pasture or prairie hay.

Protected natural vegetation provides a cover that ensures permanent stabilization of soil. To hasten the establishment of such cover, however, much work has been done in the Central Great Plains region in the artificial planting of native grasses. Results indicate that this work has not been in vain.

PLANTINGS of native grasses have in the past been limited by the small quantities of seed available. But last year, with improved machinery and methods of harvesting the seed, much larger quantities were gathered. Many pounds of western wheat and various species of grama were harvested for erosion control plantings before seeds of the bluestems had matured. Farmers in scattered areas are finding it profitable to harvest available native grass seed on their lands. The demand for the seed last year was far in excess of the supply.

In addition to planting grass on land retired from cultivation, many farmers are planting contour buffer strips of grass between strips of row crops on cultivated land. The buffer strips check the speed of run-off water from the clean cultivated strips, filter out soil particles being carried away, and cause much of the water to be absorbed. These strips, made variable in width, eliminate point rows.

Buffer strips are used on many farms without terraces. They serve as permanent guide lines for contour farming, and in most cases, afford protection from erosion during periods of torrential rainfall.

In the Central Great Plains region grass has been found useful in connection with practically all recommended soil-conservation practices. It is made to serve as guide lines for contour farming; it is proving ideal for use in field stripping; it is aiding terraces by protecting terrace outlets and outlet channels; it is an excellent permanent cover crop; it is useful in gully control; it is of first importance in the rededication to vegetation of badly eroded lands; it is proving helpful in making poor pastures more erosion-resistant and better feeding places for livestock; it thrives where fire prevention is practiced; and on farm pond dams and spillways it prevents erosion.

Home-Made Sod Cutters

WIDE usage of sodding to control erosion on small critical areas has led to the construction of simple, home-made, labor saving sod cutters in the Ohio Valley.

Fig. 1.

Figure 1 illustrates a device used in the Collierville, Tenn., camp area. Note the cutting fin welded to the point of the plowshare, and the depth gauge bolted to the beam. The moldboard turns the sod over in the conventional manner. C. C. C. enrollees follow with a truck from which planks are dropped along the slice that has been turned. The sod strip is carefully turned back on to the planks which are then loaded crosswise on to the truck, as shown in figure 4. At the sodding site, the planks are lifted to the ground and tipped so that the sod slips into place as in figure 5.

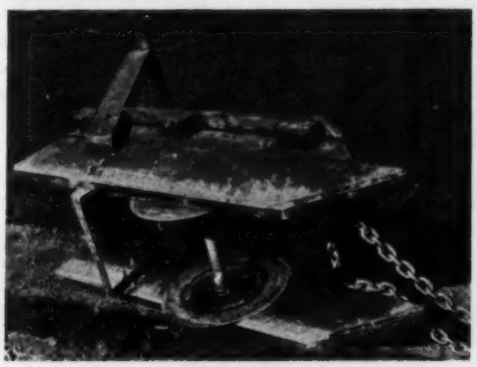

Fig. 2.

Figure 2 shows a conventional sled-type cutter, except that rolling coulters replace the usual side knives. It was built by the Mount Vernon, Ohio, project. The coulters are set to cut 4 inches deep, which is always deeper than the knife in the rear. The knife can be raised or lowered to cut sod of various thicknesses. The coulters make a cleaner cut than side knives, do not tear the sod, and prevent clogging. Experience shows that the rear knife works better if the angle is reduced to about 1½ inches in 8 inches.

To attach the coulter to the axle, it is necessary to remove the collar from the coulter, weld the collar to the axle, and then attach the coulter to the collar. This is to prevent warping of the coulter during the welding process. The pipe axle turns in the oak sled

runners. A hole is bored diagonally in the runner down to the axle for oiling, and a cut-off spike inserted to keep out dirt. The illustration suggests the strength and durability necessarily built into this machine to prevent the runners from pulling together and binding of the coulters.

Figure 3 shows the slightly different type of cutter used in the Washington, Ind., camp area. Rolling coulters divide the sod at the sides; the sharpened and tilted knife just to the rear of them cuts the sod loose underneath. Sod strips are cut in pieces by hand, ready for hauling to the place of use. This type of cutter is particularly useful for taking sod from small patches where the larger cutters cannot be conveniently handled. It can be drawn behind a ½-ton pickup or truck. It has the distinct advantage of being light and easy to handle.

Fig. 3.

Fig. 4.

Fig. 5.

Ecological Relations of Vegetation and Erosion

By Charles J. Whitfield [1]

IT is now widely recognized that vegetation is the most important factor in controlling erosion. Man can maintain, restore, modify, or control the plant cover, but to accomplish this successfully he should thoroughly understand (1) the conditions which determine the appearance and maintenance of different plants and plant types (communities) in different places, and (2) the laws which govern their development and change under the various influences to which they are subjected or exposed. Man is constantly turning natural vegetation to his own uses, as when he cuts the forests for timber or uses the grass lands for grazing purposes. This he has usually done without adequate understanding of the conditions which govern the maintenance or regeneration of the kinds of vegetation he uses, and without sufficient intelligent foresight as to the consequences in the form of tremendous losses from erosion.

Much of the native vegetation has already been exploited. Great damage has been done by cultivation, grazing, lumbering, fire, and the resultant erosion. In most instances Nature has set about to repair these losses; man, in coming to her aid, can work with Nature more effectively if he understands her technique.

Ecology, while often considered as a viewpoint applicable to all biological fields, may also be regarded as a branch of science built on dynamic principles. The ultimate object of plant ecology is to evaluate the different factors of the habitat, and to determine how

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far, singly or in combination, they affect the presence or absence, the success or failure, the vigor or weakness, of the various species and communities of plants.

Well thought out, systematic, and carefully controlled experiments on vegetation are needed everywhere if we are to obtain a really thorough knowledge and evaluation of the different factors at work in determining the success of certain types in varied habitats and of certain species in competition with others. It is not at all necessary, in most cases, for the experiments to be elaborate—the simpler the better—and many outstanding problems can be successfully attacked by the simplest means. Basic research is fundamental and oftentimes necessary, however, if corrective measures are to be developed.

Immediate Ecological Values

In any intelligent program a variety of questions arise. Careful and properly directed field work should be based on working plans. The ecological factors and processes at work in each region, and how they appear to influence the vegetation, its composition, growth, reproduction and use, must serve as a guide for such plans. By such means the best methods that can be put to use may be determined, and data may be secured which are practical and comprehensive enough to indicate the trend operation programs should take.

Ecological Concepts

Plant ecology has often been defined as the relation of plants to their environment. There are generally recognized four classes of ecological factors or features of the habitat affecting the vegetation, directly or indirectly, in such a way as to differentiate it from other vegetation. These are climatic, physiographic (topographical), edaphic (soil) and biotic (the effect of animals, including the whole of man's influence on natural vegetation). Ecologically speaking, the term "habitat" has come to mean the sum of any of these factors, so far as they have real effect in determining the existence of one species or one community of plants rather than another. Such processes as grazing, erosion, lumbering, clearing and cultivation, fire, draining and flooding, and construction affect the natural vegetation. Certain ecological concepts, such as succession and the climatic climax, are widely accepted. The application of these principles really makes ecology of value, serving such practical purposes as regeneration of vegetation, erosion control, retardation of flood waters, and conservation of wildlife.

An undisturbed vegetative type, changed by some process such as fire, if left alone over a period of time, tends to undergo a series of changes and will eventually revert back to its original state. Similarly, on bare areas, there are changes in a given definite direction—successive occupation of the area by different groups or communities of plants. This is known as succession, the different plant groups occupying the area at different or overlapping times as plant communities or vegetative types. It is a matter of observation that, while some natural plant communities maintain themselves unchanged for long periods of time, others are more or less transient, changing in character, slowly or rapidly, as the years go by.

Climax Vegetation

Those natural plant communities which undergo no further change, so long as the general conditions of the environment are unaltered, are called climax types. Climax types are generally of broad extent, as the deciduous forest, the grassland vegetation, and the alpine tundra. It has been found that these large climax types are determined by climate. Climate over an area as extended as the United States is diverse; vegetation responds to this diversity and develops according to the particular climate in, first, large groups or types, and, second, minor types within. If left undisturbed, the normal tendency would be for vegetation to develop, by the process of succession, toward the climatic climax. But man has disturbed the vegetation by the processes which have been mentioned. Under man's influence the normal tendency is for the climax types to disappear and the transient or subclimax types to occupy the ground. If vegetation is to be restored, modified or controlled, it is essential to understand that climate determines the great climaxes, while within these the soil and topographic factors become of paramount importance. The value of the climax concept is that it serves as a background or norm against which to project the changes wrought by disturbance of all kinds.

Disturbance Processes

Throughout much of the United States, man has disturbed nearly all the natural vegetation and changed its appearance from its original condition by clearing, cultivation, grazing, fire, lumbering, draining, and construction. The artificial destruction of the climax dominants through the clearing of a forest, the cultivation of the land, overgrazing of the western range, initiate secondary successions or subseres. The degree, extent, and duration of any of these disturbance processes are all factors in methods of conservation, and they find their best measure in the secondary succes-

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sions or subseres that are the universal indicators of human influences. It is evident that disturbance is the crucial process against which regulation, control, or prevention must be directed. It can thus be seen that a knowledge of subseres is of great importance because many of the practical problems in erosion control programs can be answered through an intelligent understanding of secondary successions.

In general, the climax dominants tend to come back after a shorter or longer time, provided the conditions have not been too radically changed and there are enough seed parents left in the neighborhood. The problem of finding out how long they take to come back, and what conditions may hasten or retard the process, which is the practical problem if the climax dominants are wanted for social or economic values, involves nothing more nor less than the thorough scientific study of the subsere which was initiated by the original destruction of the climax. A forest, for instance, may be carefully and economically handled so as never to interfere materially with the rejuvenation of the valuable trees. Also, a cattle range may be managed in such a way that it will provide the maximum feeding capacity from the range taken as a whole over a period of years. Such treatment means—translated into the language of succession—that the sere [2] is never thrown back farther than necessary, the subsere is kept as short as possible, conditions retarding the successions are avoided, and those favoring it are fostered or even artificially introduced. It may be, of course, that the valuable trees, or forage plants, are not the climax dominants at all, but members of an earlier phase. Then the climax is prevented from developing and the succession is not thrown back farther than is avoidable beyond the valuable phase.

Disturbance processes, and their effects upon cover and soil, serve as a basis for attacking the problem of erosion control. According to H. L. Shantz, "The whole program is primarily a job for the botanist, be he ecologist, agronomist, or forester. Under all cases, plants bind down the soil material and prevent its washing away. Erosion starts as a result of destruction of the plant cover. To reestablish this cover is a problem of agronomic or forest practice and, generally, must follow the course of secondary successions. Secondary successions are Nature's attempt to heal a wound in the earth's natural cover. The stages of reestablishment can easily be worked out, and in all cases, recovery is most rapid when there is no further interference by partial or total destruction of the plant cover. To remove continually the weeds from a deserted farm area on the high plains, is to retard the reestablishment of the short grasses. But the presence of weeds may be a sign of improvement or retrogression and only a trained ecologist can determine which process is taking place. It is all important, if man is to direct the reestablishment of our depleted range land, that he know the natural stages of revegetation, in order that he may further the natural recovery rather than retard it. Only a trained field man can determine the amount of damage done on the overgrazed ranges or to eroding soils." [3]

[2] SERE.—As a vegetation develops, the same area becomes successfully occupied by different plant communities. This process is termed "plant succession" and the successive stages "seres."

Clearing and Cultivation

Beginning with the advent of man, the clearing of the broad forest expanses with their dense undergrowths of vegetation, and cultivation of the land has exposed these forest soils to the action of water and wind. Experiments have shown that under natural conditions, run-off and erosion from forested areas is slight. W. C. Lowdermilk has demonstrated that this is due to the litter and humus which keeps the soil porous, thus allowing penetration.[4]

Exposure of soils through clearing and cultivation, especially on slopes of varying gradients, generally greatly accelerates the process of erosion, and unless effective farm management systems are initiated, the dark-colored organic matter, or humus, is carried away. The amount of percolation is greatly decreased and water is lost rather than stored. Plant foods are removed and, if the soils remain exposed, the subsoils as well as surface soil materials are washed away.

Grazing

Stock ranges in the West were originally dominated for the most part by that climax species which usually consists of strong, vigorous, palatable, perennial grass plants. The disturbance processes of heavy grazing and trampling, aided by drought, have affected these ranges and changed the vigor, density, and composition of the original vegetation. At first, vigor of plants was affected by continuous cropping, which caused a shortening of the root systems as well as a decrease in stature of the upper parts of the plant. With lessened vitality, the dominant, or climax species, were not able to compete with subdominant species. In some areas of the Southwest, for instance, continued use of the dominant black grama permitted the subdominant burro-weed to increase greatly in abundance. With

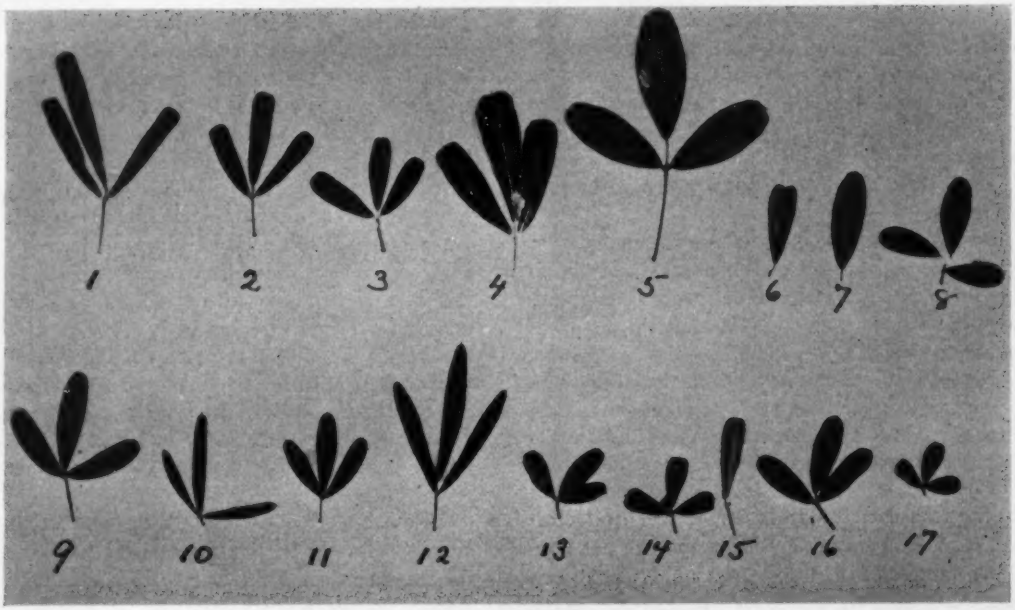
(*Continued on p. 270*)

[3] H. L. Shantz: Challenge of Erosion to Botanists. Iowa State Journal, sec. 9, pp. 353–363. 1934.

[4] W. C. Lowdermilk: Influence of Forest Litter on Run-off, Percolation and Erosion. Journal of Forestry, vol. 28, pp. 474–491. 1930.

Some Lespedeza Relationships

By A. J. Pieters [1]



***Lespedeza leaves, nearly natural size:** 1–4, L. sericea; 5–8, L. inschanica; 9–11, L. juncea; 12, L. cystoides; 13–17, L. latissima.*

THE lespedezas are of such definite interest in the soil conservation program that it is considered worth while to set down something of the taxonomic relationships of the species. No monograph of the genus has been written and it is necessary, therefore, to piece together our data from the various descriptions of the species, mostly Asiatic. P. L. Ricker, of the Division of Forage Crops and Diseases, has been working with the writer for several years on the taxonomy of the lespedezas and it is from these studies that this discussion has been drawn. The lespedezas occur as natives in only two great regions—eastern Asia as far west as the Himalayas, and eastern North America as far west as Texas. *Lespedeza sericea* has been recorded from Australia, but there is reason to believe that it is there merely as an introduction and is not truly indigenous, as is the case with the common annual in this country.

There are 125 species described under 185 names. Twenty out of the 125 species have been named from North America, though only 11 are common. This leaves 104 species in the Orient. Of this number, some 25 species have been grown in the nursery of the Bureau of Plant Industry. The American species do not occur in the Orient, nor are any oriental species indigenous to America.

Taxonomists place the species into four groups: Macrolespedeza, Eulespedeza, Campylotropsis, and Microlespedeza. The last named includes the only two annual species known, namely, *L. striata* (common lespedeza) and *L. stipulacea* (Korean lespedeza). These are so well known that they need not detain us. The first two groups are united under the term Archilespedeza, and this great group differs from the Campylotropsis group in that the keel of the flower is blunt or truncate instead of pointed and beaked, and that there are two flowers behind every bract instead of one. In general appearance some of the Macrolespedeza group resemble those of the Campylotropsis group. *L. bicolor* is an example of this in its resemblance to *L. macrocarpa*. The species of the Macrolespedeza group differ from those of the Eulespedeza group in having a four-parted instead of a five-parted calyx and in lacking the apetalous flowers; that is,

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those that have no corolla and consequently do not show. The species of the Eulespedeza group have both inconspicuous but fertile flowers and conspicuous flowers. This is also true of the two annuals of the Microlespedeza group. The species native to the United States all belong to the Eulespedeza group.

Agronomically the lespedezas may be classed as annuals or perennials, and the latter again as shrubs or herbaceous perennials. Species such as *L. bicolor* are representative of the shrubs, while our native species, *L. sericea* and *L. juncea*, represent the herbaceous perennials.

This Eulespedeza group is of special interest as it contains several species that intergrade and are so much alike that it is often difficult to be certain with which species we are dealing. This "sericea group" of species consists of *L. juncea*, *L. sericea*, *L. inschanica*, *L. cystoides*, *L. caraganae*, and *L. latissima*. The specific distinction between these species is in the shape of the leaflet, though habit of growth also differs somewhat. Typical *sericea* is strictly erect, *juncea* and *inschanica* more bushy, while *latissima* is low and either procumbent or prostrate. These habit characters, while agronomically important, are not commonly considered in making botanical descriptions which are based on characters that can be checked from an herbarium specimen.

The typical leaflet of *L. sericea* (see drawings 1 to 4 inclusive of the illustration) is narrow at the base, broadest at the apex, and with the end truncate. The midvein extends into a spine. In *L. juncea* (drawings 9, 10, and 11) the leaflet narrows toward both ends from the middle and the apex is rounded, neither truncate nor acute. In *inschanica* (5, 6, 7, and 8) the leaflet is relatively wider but of the same shape as in *juncea*. The plants tend to be larger and more open bushes than in *juncea*. *Cystoides* (drawing 12) has a long narrow leaflet acute at the apex, while *latissima* (drawings 13 to 17 inclusive) has a stubby leaflet relatively broader and shorter than in *juncea* but again of the same general shape.

While the shapes of the leaflets as given above are correct in typical cases the variations are so numerous that few plants are found on which all the leaflets are typical. The shape and proportions of the leaflets on the lower part of a plant may differ from those on the upper part. The truncate end of the *sericea* leaflet may grade into a sloping shoulder and thus closely resemble the *juncea* leaflet as is shown in drawing 3 of the illustration. On some *sericea* plants leaflets have been found as in drawing 10, and these are difficult to distinguish from the leaflets of *juncea*. The *inschanica* leaflet is sometimes narrowed as may be seen in drawing 7, and this brings its shape closer to that in *juncea* and the leaflet of *latissima*, normally short and stubby, may be longer, as in drawing 16, and then it too approaches that of *juncea*. In some leaflets of *latissima* there is an approach to the *sericea* form, although the leaflet is shorter as shown in drawing 14.

On one plant of a perfectly flat growing selection at Arlington Farm, the leaflets are like those of *sericea* (drawing 15) though the habit of growth is that of *latissima*. Of course it is possible that this strain is the result of a natural cross between *sericea* and *latissima*. In *L. caraganae*, which has not been grown at Arlington Farm, the leaflets resemble those of *sericea* but are narrower and with retuse apex. An idea of how leaflet shapes vary can be had from a study of drawings 5, 6, and 7, all of which were taken from the same herbarium specimen. That shown in drawing 5 represents the lower stem leaves, 6 was found toward the end of the branch, and 7 at the tip. The leaf shown in No. 6 is typical *sericea* and 7 very close to *juncea*.

All this has agronomic importance: without proper knowledge of the species two or more workers may use the same name and yet be working with different forms. To the soil conservationist the habit of a plant as related to its value for erosion control is of more importance than the shape of the leaflet. It would appear advisable, therefore, to select and propagate at different nurseries the strains or species that prove useful under specific conditions, leaving to the taxonomist the difficult task of applying the correct name. In some instances, there is little doubt that no two taxonomists would agree, and the same specialist might express a different opinion on two lots from the same plant.

Field men having plantings of erect plants with most of the leaflets as in drawings 1, 2, 3, and 4 can safely call them *Lespedeza sericea*. Where the plants are more bushy and less strictly erect with the leaflets, or most of them, like those in drawing 9, the species doubtless is *juncea*. It is not probable that any plantings of *inschanica* will occur, but where plants are more open in habit than are *sericea* or *juncea* and the leaflets generally larger—especially on the lower parts—they probably should be classified as *inschanica*. *L. cystoides* will not be found, and *latissima* is readily distinguished by its nearly or quite prostrate habit of growth.

Another article by Dr. Pieters, "The Native American Lespedezas," will appear in a future issue.

What We Have Learned About Terrace Spacing At Guthrie, Oklahoma

By A. E. Brandt [1] and G. W. Musgrave [2]

AN ANALYSIS of results from experiment No. 1 at the Red Plains Soil Erosion Experiment Station at Guthrie, Okla., shows that the percent of precipitation which runs off terraced land is negatively correlated with the vertical spacing of the terraces. To be specific, the average of the run-off, stated in percent, for eight rains of sufficient intensity to cause soil loss, was 54.5 for the 2-foot terraces, 46.5 for the 3.5-foot terraces and 41.7 for the 5-foot terraces.

Run-off as Percent of Precipitation for Principal Rains During 1933

Rain number	Vertical spacing		
	2 feet	3.5 feet	5 feet
1	50.4	39.0	35.4
2	59.3	69.0	58.0
3	52.6	47.3	49.0
4	25.3	20.1	12.9
5	48.0	38.6	29.2
6	72.2	58.9	53.4
7	57.1	50.8	50.8
8	69.1	48.6	43.0
Mean	54.3	46.3	41.7

Another analysis of results from the same terraces shows that the percent of precipitation lost as run-off tends to be positively correlated with vertical spacing, but that either the 2-foot or 5-foot spacing is quite superior to the 3.5-foot spacing for conserving water.

Run-off as Percent of Precipitation for Principal Rains During 1936

Rain number	Vertical spacing		
	2 feet	3.5 feet	5 feet
1	38.5	47.8	38.1
2	25.4	32.8	22.0
3	21.8	27.6	22.6
4	71.5	75.4	63.3
5	53.8	52.5	38.4
6	0	45.8	36.4
Mean	35.2	47.0	36.8

A third analysis of data from the same terraces shows, as does the first analysis, that the percent of precipitation lost as run-off is negatively correlated with vertical spacing, but the 5-foot spacing shows a greater superiority than previously. As in the second study, however, the 3.5-foot spacing is not in line with the other two spacings—that is, there is a difference in run-off of 2.4 percent between the 2-foot and 3.5-foot spacings but that between the 3.5-foot and 5-foot spacings is nearly seven times as great, 16.6 percent.

Run-off as Percent of Precipitation for Principal Rains During 1935

Rain number	Vertical spacing		
	2 feet	3.5 feet	5 feet
1	18.8	22.4	6.2
2	66.5	53.0	34.8
3	41.5	62.3	24.8
4	79.2	86.7	44.2
5	64.4	56.4	31.0
6	70.8	68.7	70.1
7	98.7	93.1	77.5
8	32.6	26.0	25.2
9	84.8	67.0	62.3
Mean	61.9	59.5	42.9

Ecologic Research

Many writers, especially those searching the literature for evidence to prove a point, select data such as tabled above. It is customary in such instances to say that a close study or a statistical study shows conclusively, or proves beyond doubt, that the particular thesis is true. Generally speaking, such a person is an upright and honest searcher after truth and he feels that because some numbers add up in a special way in the table presented by him, the point has been proved. Unfortunately a conclusion reached in this manner is liable to be erroneous as only the magnitude of a difference has been considered whereas it is essential to consider its probable range of variation as well. An estimate of this probable range of variation can be secured if the treatments or experimentally controlled variables are replicated, but it will be valid only if properly randomized.

This variation or variability is the basis of the modern statistical advances concerning tests of significance and the design of field experiments. Some research workers are inclined to blame modern statisticians and modern experimental designs for this

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variability and its prominent place in research when, as a matter of fact, it is inherent in the living material used in the experiments. Though this matter of unreliability of results from experiments is a very live subject of discussion, it is not new. Robert Boyle, writing in 1763 "concerning the unsuccessfulness of experiments" said, "I am very sorry, Pyrophilus, that to the many (elsewhere enumerated) difficulties which you may meet with, and must therefore surmount, in the serious and effectual prosecution of experimental philosophy I must add one discouragement more, which will perhaps as much surprise as dishearten you; and it is, that besides that you will find (as we elsewhere mention) many of the experiments published by authors, or related to you by the persons you converse with, false and unsuccessful (besides this, I say), you will meet with several observations and experiments, which, though communicated for true by candid authors or undistrusted eyewitnesses, or perhaps recommended by your own experience may, upon further trial, disappoint your expectation, either not at all succeeding constantly or at least varying much from what you expected."

A somewhat common belief among field experimenters is that an exact and invariable answer to a given question can be secured if conditions can be so controlled that there is but one variable. A weakness in this argument is apparent if one considers that but a few sources of variability can be controlled and the variability from other sources is ignored. It is often argued, however, that if a representative field of sufficient size be used these other sources of variability need not be considered.

Experiment No. 1, data from which are presented in tables 1, 2, and 3, consists of 6 terraces each 700 feet long with a channel grade of 4 inches per hundred feet placed on a uniform slope at vertical spacings 2, 3.5, and 5 feet. The numbers of the terraces and their vertical spacings are: 1E, 2 feet; 2E, 3.5 feet; 3E, 5 feet; 4E, 5 feet; 5E, 3.5 feet; and 6E, 2 feet. The numbering runs from the bottom of the slope to the top. Records of the percent of precipitation lost as run-off, and of the soil lost, were kept for the years 1932 to 1936, inclusive. The records for those rains which produced measurable soil loss are used as a basis for this study.

The figures in the body of each of the tables (1, 2, and 3) are the means of two terraces of the same slope for the years 1933, 1936, and 1935, respectively. In view of the apparent contradictions displayed in the tables above, the question naturally arises as to whether or not the data for the entire period are consistent enough for any inferences to be made.

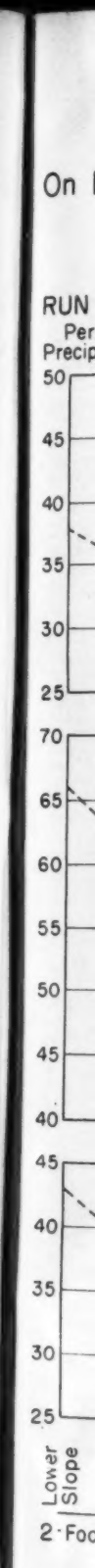
By a rather simple arithmetic process, it was found that there is a very definite tendency for the percent of precipitation lost as run-off to be greater from terraces having a 2-foot vertical spacing than from those having a 5-foot spacing. For a given slope, the distance between terraces is less for a 2-foot vertical spacing than for a 5-foot spacing, resulting in a shorter time for concentration of water in the terrace channel for the narrower spacing which diminishes the effective time during which the soil may absorb the water running over its surface. It seems that the inference is logical.

There is a tendency for the run-off from the terraces having a 3.5-foot spacing to be greater than the mean for those having 2-foot and 5-foot spacing. Though the evidence provided by this experiment is not strong enough to generalize, this point should be kept in mind in further studies.

The totals for the 5-year period show a tendency toward the loss of a larger percent of precipitation from terraces in the lower half of the slope than from those in the upper half but this varies too greatly between spacings and years to be of much significance.

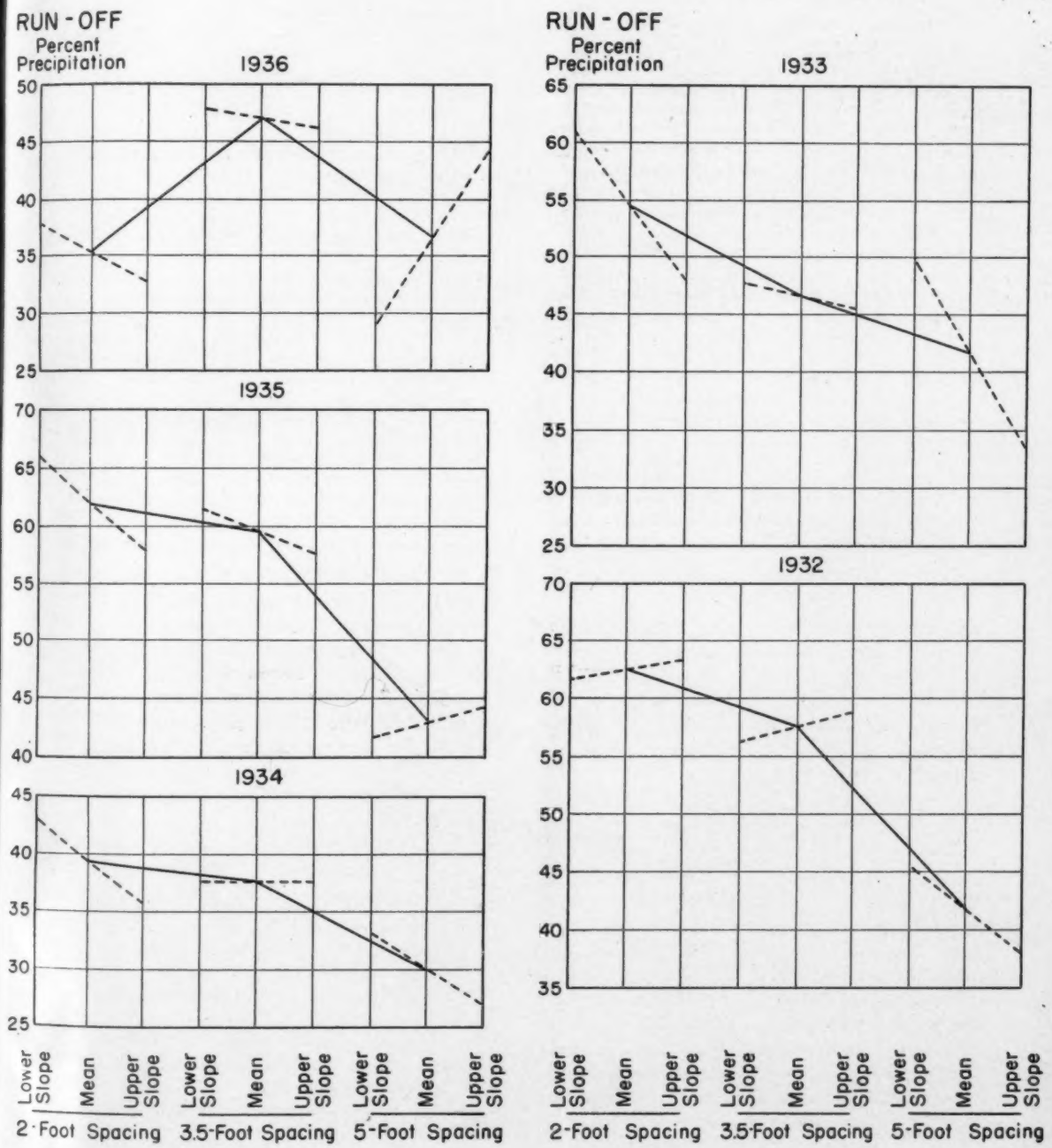
The data from this experiment are herein presented in graphical form. By plotting the mean annual run-off from the two terraces at each spacing against the spacing for each year, a general impression of the tendency of percent run-off to be negatively correlated with vertical spacing is given while the picture of yearly variation is retained. A more complete picture of the variability encountered is given by plotting the results from each terrace for a given spacing in addition to the mean.

A similar examination of the data on soil loss in tons per acre from the six terraces over the 5 years was made. The totals indicate that the soil loss is greater from the 5-foot terraces than from the 2-foot, but when this difference is compared with the variability in the results from terraces of the same spacing it hardly seems significant. This situation may indicate three distinct answers as follows: First, that the terraces of the different vertical spacings are equally effective in controlling erosion; second, that the method of measuring soil loss reflects only the behavior of the terrace outlets which were alike in this experiment and not the soil movement or erosion throughout the whole terrace area; or, third, that the method of measuring soil loss is so inaccurate as to increase unduly the variability of results from a given terrace. If either of the first two answers is correct, a change in the design should determine which within a few years' time. If, however, there is a bias due to inaccuracy of the determination of soil loss, no amount of experimentation with the same or a different design will correct it.



RELATION OF VERTICAL SPACING OF TERRACES TO RUN-OFF

On Experiment Number 1 —— At Red Plains Erosion Experiment Station



BOOK REVIEWS AND ABSTRACTS

By Phoebe O'Neall Faris

TERRACING FOR SOIL AND WATER CONSERVATION. By C. L. Hamilton. U.S. Department of Agriculture Farmers' Bulletin 1789. Washington, D. C. April 1938.

This bulletin has as its objective the proper construction of terraces and suitable supplemental tillage practices to ensure good farm crop production on sloping agricultural lands without excessive soil loss. The detailed discussion incorporates the experiences and studies of the engineering section of the Soil Conservation Service and, in addition, a great deal of valuable information collected by field engineers at various soil and water conservation experiment stations. This, together with specific directions for terrace construction and farming practices on terraced lands, constitutes a most valuable compilation of the best information now available on the subject.

As the first factors to be considered in terrace system designing, the surface slope and rate and velocity of run-off are emphasized, and types of terraces for surface drainage and to increase rainfall absorption in the control of wind erosion are described as to function and adaptability. Photographs and cross-section charts illustrate the bench terrace for use on steeper slopes and show the inverted soil profile as developed by soil movement between terraces. The author then points out the fundamental principles involved in planning the terrace system—slope and soil observations, division lines between terracing units, natural and special outlets, diversion or interception ditches, tillage equipment available, and cropping practices to be employed ". . . to improve the soil fertility, reduce the annual soil movements between terraces, and minimize terrace maintenance."

As the result of experimentation, Mr. Hamilton presents specifications for limiting land slopes and for terrace spacings, grades, lengths, and cross-sectional areas. A table included with the text gives recommended vertical intervals between terraces on various slopes and the corresponding horizontal distances, acreage of each terrace interval per mile or per 100 feet of terrace, and the feet of terrace required per acre of land. A graphic presentation of the tabular information is presented for the convenience of contractors, terrace surveyors, engineers, and farmers who prefer this medium for determining specifications for terraces on various slopes and acreages in both Northern and Southern States. Careful directions are given for using the chart.

The author states that preliminary staking is important in laying out the terrace system in order that all topographical features be accounted for, and that realinement is usually necessary on each proposed terrace ". . . to eliminate undesirable sharp curves, to obtain greater ease of construction, and to secure a finished terrace that will offer a minimum of inconvenience in later tillage operations." Before construction begins, the final check of the terrace and outlet locations should show that the entire lay-out will be satisfactory.

An especially useful section of the bulletin is that dealing with terracing equipment, as developed and improved within the past few years. Because of the importance of proper equipment for terrace construction, this issue of SOIL CONSERVATION is showing, on the back cover, a series of drawings illustrating the progression of terrace machinery.

ECOLOGICAL RELATIONS

(Continued from p. 264)

lessened vigor, reproduction also is affected and plants generally decrease in density; the composition of the stand is changed; the soil is exposed to erosion and run-off, and as in cleared areas the water fails to penetrate the soil to any appreciable extent. Under these conditions, the habitat cannot support as good a vegetative cover as the original one.

It is generally found that over much of our western range lands where once desirable species grew, less desirable species provide the present cover. The area is so vast that all stages of destruction occur at the present time. Some of the damaged ranges, as in the Great Plains and in higher elevations of mountainous regions, can be improved by proper range practice in relatively short periods of time. In other areas, as parts of the Southwest, heavy utilization has greatly impoverished the vegetation. To develop climax vegetation which has been destroyed, especially in critical areas subjected to frequent droughts, is probably not a matter of years but of centuries. [5]

[5] H. L. Shantz. ibid:

The other disturbance processes, such as fire, lumbering, draining, flooding, and construction, all have a tendency to destroy the cover, impoverish the soil and set the stage for induced erosion. However, an understanding of secondary successions will put an important tool in the hands of field workers whose problem it is to check erosion, reestablish a vegetative cover and improve the forage and timber resources. If the subject is to be dealt with intelligently and to the greatest advantage, it is not sufficient merely to record the existence and quantity of vegetation, but it is necessary also to study its behavior and potentialities.

In addition to the specific citations, material for this discussion was drawn freely from the following references:

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